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QUATERNARY AMMONIUM BACTERICIDES

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This invention pertains generally to quaternary ammonium compounds and particularly to high activity quaternary ammonium bactericides containing one or more chlorinated benzyl groups.

The prior art has known of quaternary ammonium compounds having a structure such as n-alkyl dimethyl dichlorobenzylammonium chloride (cf. British Patent No. 458,033). Compounds with a similar structure except for a third chlorine atom on the benzene ring have also been known. U.S. Patent 2,700,683 also discloses an analogous compound, suggesting that one or two chlorine atoms can be substituted for the hydrogen in the benzene ring.

The foregoing, and closely related compounds, have interesting bactericidal properties. However, we have now found bactericides which are far more potent, even when used in hard water, may be obtained by mixing n-dodecyl dimethyl 2,4-dichlorobenzylammonium chloride together with (*a*) n-tetradecyl dimethyl 2,4-dichlorobenzylammonium chloride, or (*b*) n-tetradecyl dimethyl benzylammonium chloride, or with both compounds (*a*) and (*b*). The surprising results of these mixtures are remarkable synergistic effects, the products being formed thereby having bactericidal efficiencies in hard water which far surpass the performance of any one of the components when acting alone. In fact, in the case of two of the three components, the ineffectiveness of their individual bactericidal action is so marked that they fail individually to meet stringent minimum standards utilized by industry to determine the comparative usefulness of different germicides in certain sanitation applications employing water having relatively high hardnesses. Yet, when these same components are combined in accordance with our invention, the results are compositions which are capable of exceeding those standards by wide margins. Moreover, the bactericidal effectiveness of even the third component is remarkably increased when combined with one or both of the other, individually unacceptable components.

It is thus a principal object of the present invention to provide compounds which have valuable bactericidal properties that are highly effective even in the presence of very hard water.

It is a further object to provide compositions that comply with the standards of the United States Department of Public Health and of industry in certain sanitation applications such as the sanitizing of food utensils, particularly in the presence of waters of considerable hardness.

A still further object is to provide improved methods for controlling bacteria in aqueous systems by means of the addition of improved bactericides.

One more object is to provide improved aqueous systems containing very hard water and a bactericide capable of controlling bacteria therein so as to meet extremely stringent health requirements.

All of these objects have been accomplished by forming, and employing in aqueous solutions, mixtures of the type described generally above and more in detail below. As an indication of the manner in which these objects have been achieved, consideration should be given to the following evaluations of our novel compositions which were made according to the standard Chambers modification of the Weber-Black test (Weber, G. R., and Black, L. A., Journal of the American Public Health Association, 38, 1405 [1948]). This test consists of introducing specified bacteria, in a known amount, into a predetermined volume of water, then adding a known concentration of the bactericide to be tested and, finally, determining the percentage of bacteria killed at certain specified intervals of time. Usually, a 100-milliliter sample of test solution is employed, consisting of one milliliter of the inoculum, one milliliter of an aqueous solution of the bactericide tested, and the remainder of hard water. The bacteria employed are present in the amount of between 75,000,000 and 125,000,000 per milliliter of test solution. The bactericide is added at any desired concentration. The water employed may be distilled or natural water.

In the present evaluation, 100 milliliters of test solution was employed, consisting of one milliliter of an inoculum containing *Escherichia coli* USPHS #198, strain ATCC #11229, in an amount to give between 75,000,000 and 125,000,000 bacteria per milliliter of the test solution at the start of the test, one milliliter of the subject bactericide in an amount to give 200 parts per million of the test solution, and the remainder of synthetic hard waters. The water employed had controlled, varying hardnesses, each equivalent to a stated number of parts per million as calcium carbonate.

In the following tables, there are shown the results of the modified Chambers test conducted on the unique compositions of our invention, and separately on each of the components thereof. In order for a bactericide to be approved by the United States Department of Health, it must kill at least 99.999 percent of the specified number of *Escherichia coli* present in 30 seconds. This kill must take place upon employment of a concentration in water of 200 p.p.m. of active ingredient.

Quaternary ammonium type bactericides of the prior art, as typified by the alkyl dimethyl chlorobenzylammonium chlorides, have been known to have a hard water ceiling rating of between 500 and 800 p.p.m. However, in many parts of the world, the water is much harder. Thus, a bactericide which possesses a hard water ceiling on the order of 850 p.p.m. or more is considered to be quite exceptional. With this in mind, the data in the tables represent comparisons of the various mixtures (at varying concentrations of the components) of the present invention to show at what level of water hardness values they may be employed before they begin to lose their bactericidal activity. In each table, the values which are also given for each component, separately, make it convenient to compare therewith the synergistic results of the mixtures represented in every combination except those shown in Table III.

TABLE I

Compound A=n-dodecyl dimethyl 2,4-dichlorobenzylammonium chloride.
Compound B=n-tetradecyl dimethyl 2,4-dichlorobenzylammonium chloride.

Percent A (by weight)	Percent B (by weight)	Hard Water Ceiling (Chambers Test), p.p.m.
100	0	750
80	20	1,150
60	40	1,350
50	50	1,350
40	60	1,350
20	80	1,200
0	100	1,050

TABLE II

Compound A=n-dodecyl dimethyl 2,4-dichlorobenzylammonium chloride.
Compound C=n-tetradecyl dimethyl benzyl ammonium chloride.

Percent A (by weight)	Percent C (by weight)	Hard Water Ceiling (Chambers Test), p.p.m.
100	0	750
80	20	1,200
60	40	1,150
50	50	1,150
40	60	1,150
20	80	850
0	100	800

It is immediately apparent that the bactericidal effectiveness in hard water of the compositions formed by mixing compounds A and B is far greater than that of either A or B alone, and the corresponding effectiveness of the compositions formed by mixing compounds A and C is far greater than the germicidal activity of either A or C alone. Moreover, even the minimum hard water ceilings of such mixtures match or exceed the level of acceptability which, as mentioned above, is considered to be exceptional. Compounds A and C fall far below that level when each is used alone; only compound B exceeds it. But when compounds A and C are mixed together, the result is a composition which far surpasses the bactericidal activity in hard water of either A or C. Likewise, when A and B are mixed together, the result is a composition which not only is within acceptable limits but also far surpasses the low level of acceptability possessed by B.

The marked synergistic effect of the binary compositions formed by mixing together either compounds A and B or compounds A and C is all the more outstanding in view of the fact that mixtures of compounds B and C produce no such effect. Instead, all that results is a hard water ceiling, at each ratio of the two compounds, which appears to be directly proportional to the respective amounts of each one that is present in any particular mixture. Table III illustrates this as follows:

TABLE III

Compound C=n-tetradecyl dimethyl benzyl ammonium chloride.
Compound B=n-tetradecyl dimethyl 2,4-dichlorobenzylammonium chloride.

Percent B (by weight)	Percent C (by weight)	Hard Water Ceiling (Chambers Test), p.p.m.
100	0	1,050
80	20	1,000
60	40	950
40	60	900
20	80	850
0	100	800

Although a binary mixture of B and C produces no synergistic effect, a ternary mixture of A, B, and C does. This is illustrated by Table IV, as follows:

TABLE IV

Compound A=n-dodecyl dimethyl 2,4-dichlorobenzylammonium chloride.
Compound B=n-tetradecyl dimethyl 2,4-dichlorobenzylammonium chloride.
Compound C=n-tetradecyl dimethyl benzyl ammonium chloride.

Percent A (by weight)	Percent B (by weight)	Percent C (by weight)	Hard Water Ceiling (Chambers) Test), p.p.m.
100	0	0	750
0	100	0	1,050
0	0	100	800
10	30	60	900
10	60	30	1,000
30	10	60	1,050
30	60	10	1,200
60	10	30	1,200
60	30	10	1,300

At least about 10 percent of each of the three components preferably should be present in order to obtain the desired results from this ternary mixture, the balance of 90 percent being made up by the other components in any suitable proportion.

The foregoing illustrates that our invention may be practiced by mixing n-dodecyl dimethyl 2,4-dichlorobenzylammonium chloride (compound A) with either n-tetradecyl dimethyl 2,4-dichlorobenzylammonium chloride (compound B), or n-tetradecyl dimethyl benzylammonium chloride (compound C), or both. The proportions of the respective binary or ternary mixtures may be varied in practically any combination, the only difference between them being that some of the combinations are more effective bactericidally than the others.

The compositions of the present invention are capable of eliminating all, and not merely reducing a portion, of such bacteria as *Escherichia coli* even at lesser concentrations than the 200 p.p.m. of active ingredient mentioned in the test described above. It is preferable, however, to use that minimum amount since it is well known that *Escherichia coli*, whose presence in water is an indication of fecal pollution, causes many infections such as in the kidneys, urinary bladder, and gall bladder, among others.

Our novel compositions may either be employed alone or in a detergent sanitizer formulation, as desired. They may be formulated with a non-ionic detergent such as an alkylarylpolyethoxyethanol for use in restaurants, hotels, and the like for sanitizing food utensils. They may also be used in formulations with a non-ionic detergent, such as an alkylarylpolyethoxyethanol, along with, if desired, sodium metasilicate, sodium phosphates of various types, sodium carbonate, sodium bicarbonate, urea, sodium sulfate, or the like, singly or in combination. Examples of such uses are in dairy plants to sanitize milk cans, pipe lines and such, in food plants to sanitize food machinery, and on farms for sanitizing equipment and cleaning eggs.

Examples of the preparation of the compounds employed in making the compositions of the present invention, as well as of the preparation of the novel compositions themselves, are as follows:

EXAMPLE 1

Preparation of dodecyldimethyl-2,4-dichlorobenzylammonium chloride

Into a 500-ml., three-neck, round-bottomed flask fitted with an agitator, a water-cooled condenser, and a thermometer was charged 106.5 grams (0.5 mole) of dodecyldimethylamine, 95.5 grams (0.49 mole) of 2,4-dichlorobenzyl chloride, and 168 grams of water. The heterogeneous mixture was heated with stirring to 60° C. and

held for 2½ to 3½ hours at 60°–65° C., during which time the system became a homogeneous, clear, nearly colorless liquid. A sample was withdrawn for analysis. Using standard analytical procedures, the composition was found to be:

	Percent
Quaternary	53.6
Amine	0.16
Amine hydrochloride	0.44

The preparation was diluted with water to yield a solution of 50 percent active ingredient.

EXAMPLE 2

Preparation of teradecyldimethyl-2,4-dichlorobenzylammonium chloride

A solution of 50 percent active ingredient was prepared as in (1) above using tetradecyldimethylamine instead of dodecyldimethylamine.

EXAMPLE 3

Preparation of tetradecyldimethylbenzylammonium chloride

A solution of 50 percent active ingredient was prepared as in (2) above using benzyl chloride instead of 2,4-dichlorobenzyl chloride, and charging anhydrous ethanol to the initial reaction vessel in an amount that corresponds to 7 percent by weight of the total charge.

EXAMPLE 4

Preparation of binary mixture of quaternaries

Binary mixtures of quaternaries were prepared by charging the above described 50 percent solutions to a suitable reaction vessel in their proper weight amounts and blending them by thorough mixing.

EXAMPLE 5

Preparation of ternary mixture of quaternaries

Ternary mixtures of quaternaries were prepared by charging

60 parts of a 50 percent solution of n-tetradecyl dimethyl benzyl ammonium chloride,
30 parts of a 50 percent solution of n-tetradecyl dimethyl 2,4-dichlorobenzylammonium chloride, and
10 parts of a 50 percent solution of n-dodecyl dimethyl 2,4-dichlorobenzylammonium chloride

(all of said solutions being made by diluting each of the concentrated compositions with water), to a suitable reaction vessel in their proper weight amounts and blending them by thorough mixing.

In the same way, mixtures were prepared in the various other proportions of the several quaternaries as indicated in Table IV.

We claim:

1. A high activity quaternary ammonium bactericide comprising as its essential active ingredients a mixture of from about 20 percent to about 80 percent of n-dodecyl dimethyl 2,4-dichlorobenzylammonium chloride and from about 20 percent to about 80 percent of at least one member from the class consisting of n-tetradecyl dimethyl 2,4-dichlorobenzylammonium chloride and n-tetradecyl dimethyl benzylammonium chloride.

2. A high activity quaternary ammonium bactericide comprising as its essential active ingredients a binary mixture of from about 20 percent to about 80 percent of n-dodecyl 2,4-dichlorobenzylammonium chloride and from about 80 percent to about 20 percent n-tetradecyl dimethyl 2,4-dichlorobenzylammonium chloride.

3. The binary mixture of claim 2 in which there is present approximately 50 percent of each component thereof.

4. A high activity quaternary ammonium bactericide comprising as its essential active ingredients a binary mixture of from about 20 percent to about 80 percent of n-dodecyl dimethyl 2,4-dichlorobenzylammonium chloride and from about 80 percent to about 20 percent of n-tretradecyl dimethyl benzylammonium chloride.

5. The binary mixture of claim 4 in which there is present approximately 50 percent of each component thereof.

6. A high activity quaternary ammonium bactericide comprising as its essential active ingredients a ternary mixture of n-dodecyl dimethyl 2,4-dichlorobenzylammonium chloride, n-tetradecyl dimethyl 2,4-dichlorobenzylammonium chloride and n-tetradecyl dimethyl benzylammonium chloride in which the minimum amount present of any one of the three components is about 10 percent of the entire mixture, the balance of 90 percent being made up essentially by the other two components which are present in amounts ranging from about 80 percent of the entire mixture.

7. A method for controlling bacteria in aqueous systems which comprises adding to the water a high activity quaternary ammonium bactericide comprising as its essential active ingredients a mixture of from about 20 percent to about 80 percent of n-dodecyl dimethyl 2,4-dichlorobenzylammonium chloride and from about 20 percent to about 80 percent of at least one member from the class consisting of n-tetradecyl dimethyl 2,4-dichlorobenzylammonium chloride and n-tetradecyl dimethyl benzylammonium chloride.

8. The method of claim 7 in which the essential active ingredients in the bactericide consist of a binary mixture of from about 20 percent to about 80 percent of n-dodecyl dimethyl 2,4-dichlorobenzylammonium chloride and from about 20 percent to about 80 percent of n-tetradecyl dimethyl 2,4-dichlorobenzylammonium chloride.

9. The method of claim 7 in which the essential active ingredients in the bactericide consist of a binary mixture of from about 20 percent to about 80 percent of n-dodecyl dimethyl 2,4-dichlorobenzylammonium chloride and from about 20 percent to about 80 percent of n-tetradecyl dimethyl benzylammonium chloride.

10. The method of claim 7 in which the essential active ingredients in the bactericide consists of a ternary mixture of n-dodecyl dimethyl 2,4-dichlorobenzylammonium chloride, n-tetradecyl dimethyl 2,4-dichlorobenzylammonium chloride, and n-tetradecyl dimethyl benzylammonium chloride in which the minimum amount present of any one of the three components is about 10 percent of the entire mixture, the balance of 90 percent essentially being made up by the other two components which are present in amounts ranging from about 10 to about 80 percent of the entire mixture.

11. The method of claim 8 in which there is present in the binary mixture approximately 50 percent of each component thereof.

12. The method of claim 9 in which there is present in the binary mixture approximately 50 percent of each component thereof.

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UNITED STATES PATENT OFFICE

CERTIFICATE OF CORRECTION

Patent No. 2,951,787 September 6, 1960

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It is hereby certified that error appears in the printed specification of the above numbered patent requiring correction and that the said Letters Patent should read as corrected below.

Column 6, line 21, after "from" insert -- about 10 percent to --.

Signed and sealed this 4th day of April 1961.

(SEAL)

Attest: ERNEST W. SWIDER

XXXXXXXXX
Attesting Officer

ARTHUR W. CROCKER
Acting Commissioner of Patents